

REVIEW

Effects of ageing on touch

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A decline in the main sensory modalities is well reported to occur with ageing. This article outlines the normal pathways involved in touch sensation and includes a review of available evidence relating to the study of ageing and touch. The authors try to use what is known about the neuroanatomy and neurophysiology of ageing to explain the impact on some broad functional deficits seen in the elderly population. The importance of understanding how the normal ageing process affects touch sensation is emphasised.

Given that a decline in the main sensory modalities (vision, hearing, taste, and smell) is well reported to occur with advancing age, one would expect similar change to occur with touch sensation and perception. However, studying and interpreting the effects of ageing on touch is difficult.

Some studies have emphasised the role of central factors in pain perception showing that central nervous system activation associated with processing painful stimuli is reduced in the elderly.¹ Others have focused on the peripheral components of touch perception highlighting that ageing influences several morphological and functional features of the peripheral nervous system. It is probable that a combination of both contribute to the effect of ageing on touch sensation.²

THE SENSORY PATHWAYS

All sensory neuron cell bodies are in the dorsal root ganglia. The distal extensions of these cells make up the sensory nerves and the proximal projections form the dorsal roots that enter the spinal cord. Each dorsal root contains all the fibres from skin, muscles, connective tissue, ligaments, tendons, joints, bones, and viscera that lie within the distribution of a single body segment.

Two types of afferent fibres exist that respond to nociceptive stimuli: the very fine, unmyelinated, slowly conducting C fibres and the thinly myelinated more rapidly conducting Aδ fibres. There seem to be three broad categories of receptor: mechanoreceptors, thermoreceptors, and polymodal nociceptors. Information from mechanical stimulation is carried via both Aδ fibres and C fibres, and thermal stimulation largely via C fibres. Certain Aδ fibres respond to light touch, temperature, and pressure as well as pain.

The spinothalamic tracts that convey pain and temperature sensation in the spinal cord cross

within the spinal cord and reach the contralateral cortex via either the thalamus or the brain stem reticular formation. Fibres for touch sensation, as well as those mediating the sense of touch-pressure, vibration, direction of movement and position of joints, stereoaesthesia (recognition of surface texture, shape, numbers, and figures written on the skin), and two point discrimination, lie within the dorsal columns, and these also cross the midline, but at a more rostral level in the medulla, and ascend as the medial lemniscus to the posterior thalamus. From the thalamus, information is relayed to the somatosensory cortex via the thalamocortical fibres.

Perception of sensory stimuli involves higher functions of the cerebral cortex other than the sensory cortex where the stimuli are initially processed. The conscious awareness or perception of pain occurs only when the pain impulses reach the thalamocortical level, but precisely how this occurs is not fully understood.³

AGEING IN THE NERVOUS SYSTEM

The central nervous system

The male brain decreases in weight on average by 200 grams during the third to tenth decades of life, accelerating loss between the sixth and seventh decades. This loss in weight has been attributed to neuronal degeneration and replacement gliosis although this has not been proved. Most studies suggest the bulk of depletion of cortical neurons occur between the seventh to ninth decades, which parallels the decrease in brain weight. Not all neuronal groups are equally susceptible, for example, the vestibular nuclei maintain a roughly constant number of neurons throughout life whereas the locus coeruleus and substantia nigra lose about 35% of neurons with ageing.

Along with neuronal loss, the healthy ageing brain has an increased tendency to develop neuritic plaques, and by the ninth decade, few normal brains are without plaques. Other changes include accumulation of lipofuscin, iron and other pigment bodies, a decrease in the concentration of acetylcholine, noradrenaline, dopamine, GABA and NMDA receptors, and a reduction in the components of myelin and intracellular enzymes.⁴ These changes, and probably others, contribute to the slowing in central processing of sensory stimuli that can be seen by neuropsychological evaluations. Slower acquisition of new information as well as a decline in "fluid intelligence" (that is, "on the spot" reasoning ability) also occur with ageing.⁵

This article is part of a series on ageing edited by Professor Chris Bulpitt.

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The peripheral nervous system

Changes within the ageing peripheral nervous system have been more clearly reported. These include degeneration of the anterior horn cell, neuromuscular junction, muscle and dorsal root ganglia⁶ along with a reduction in the density of myelinated fibres in the spinal roots accompanied by a proliferation of satellite cells.⁷ The reduction in myelinated fibres in the fasciculus gracilis is more apparent at the rostral levels suggesting that with increasing age there is distal degeneration of afferent fibres passing centrally.⁸ Ageing also leads to a progressive loss of cells and fibres in the sympathetic outflow tract, with an estimated loss of 8% of preganglionic cell bodies per decade in the intermediolateral columns of the midthoracic region.⁹

Distally in the peripheral nervous system, reduction of total fibre number and density in the anterior tibial and sural nerves has been reported. Also noted are axonal degeneration and internodal length variability with short internodes suggesting regeneration.^{10–12} The capacity for axonal regeneration and reinnervation is maintained throughout life, but tends to be delayed and less effective with ageing.¹³

The slowing of motor and sensory conduction velocity with ageing correlates with these histological changes. The clinical features are decreased vibration sense, depressed ankle jerks, and impaired tactile sensation.

TACTILE THRESHOLDS IN AGEING

Several studies have compared sensory threshold testing in young and elderly groups of healthy subjects. Kenshalo *et al*¹⁴ compared absolute thresholds to cutaneous stimulation at two sites (thenar eminence and plantar foot) in young (age range 19–31 years) and old (age range 55–84 years) subjects. The six modalities studied were tactile, vibration at 40 and 250 Hz, temperature increase and decrease, and noxious heat. Older subjects were significantly less sensitive to mechanical stimuli (tactile and vibration) at both sites and elderly feet were significantly less sensitive than the young to warm stimuli. All older subjects showed deficits to one or more of the sensory modalities in at least one site.

Light touch

Tactile thresholds in the elderly are significantly increased.^{15–16} This is thought possibly to be attributable to a decrease in the density and distribution of Pacinian and Meissner corpuscles and Merkel's discs in the skin causing decreased spatial acuity.^{17–20}

Pain and temperature

There is an increase in thermal pain thresholds in the elderly^{21–23} and in pain threshold to transcutaneous electrical nerve stimulation,²⁴ although one study showed no age related change in the later.²⁵ Nociceptive information is conveyed to the central nervous system via myelinated (A δ) and unmyelinated (C) primary afferent fibres^{26–27} with conduction velocities of 20–25 m/s and 0.5–2.0 m/s respectively.²⁸ These fibres are thought to subserve different aspects of the pain experience. A δ fibres mediate phasic (epicritic) pain associated with early warning of a noxious stimulus and is described as sharp and prickly in nature. Ageing seems to produce a change in A δ function only²⁴ and therefore pain and temperature perception in the elderly is mostly dependent on the slower conducting C fibres.

Vibration sense

Detection thresholds for several vibration intensities are higher in older subjects.^{29–34} A study looking at 12 performance based tests of muscle strength, balance, gait, somatosensory discrimination, and reaction time showed that all these declined with increasing age and on a percentage scale, vibration threshold was the most rapidly affected by age³⁵ and is maximal after the

age of 65 years.³⁶ In non-diabetic elderly subjects loss of vibration sense is particularly pronounced but perception of light touch and pain are comparatively preserved.³⁷

Spatial acuity of touch

The spatial acuity of skin at the fingertip deteriorates noticeably with age as assessed by two point threshold measurement.³⁸ Other tests of skin spatial acuity (for example, the ability to discriminate tactile gaps, orientation of lines, and the length of lines drawn on the skin) also deteriorate with age (about a 1% increase in threshold per annum between ages 20 to 80 years).^{39–40} Tactile acuity thresholds in the foot and finger are on average about 80% higher in the older subjects (age >65 years) than in the younger subjects (age 18–28 years), but only 22% higher in the forearm. It seems that the rate of deterioration of skin spatial acuity is slower at the proximal compared with distal sites.^{41–42} Although the upper surface of the fingertip is more sensitive than the lower surface in both young and old subjects, the age related decline in tactile acuity is almost identical at both sites. The same also applies to the foot and suggests that the effect of ageing on the extremities is unlikely to be simply attributable to wear and tear on the contact surfaces of the hands and feet.

Skin changes and touch

It is not clear how much skin change itself contributes to change of touch sensation in the elderly. One study found that skin hydration did not affect vibrotactile detection thresholds but did affect perception of textured surfaces.⁴³ Skin conformance—measured as the degree to which the skin invades the spaces in the physical stimuli—has been found to be identical in both young and old subjects.⁴⁴

NERVE CONDUCTION STUDIES

There is a decline in sensory nerve conduction velocity and in the amplitude of the sensory action potential with age.⁴⁵ However, there are discrepancies amongst several studies regarding the rate of decline.¹³

Rivner *et al*⁴⁶ retrospectively analysed neurophysiological studies on nearly 4000 clinically normal subjects aged between 20 and 95 years and found strong correlation of ageing with amplitude of the sensory action potential and a small but definite negative relation between age and sensory nerve conduction velocity. In a small proportion of healthy people a response could not be recorded in at least one nerve. Below the age of 50 years this was less than 1% of subjects, whereas after the age of 70 years, a significant percentage of normal subjects had an absence of at least one nerve response. In normal subjects ulnar nerve responses were rarely absent but the sural sensory response was absent in 23% of subjects between the ages of 70 and 79 years and in 40% over the age of 80 years. This suggests that in practice, the isolated absence of a sural response in an elderly subject is probably of no clinical significance.

Elderly subjects have a raised threshold for perception of electrical stimuli compared with younger subjects.⁴⁷ One explanation for this is the progressive loss of cutaneous afferent axons and changes to cutaneous receptors. At a given stimulus strength, fewer sensory axons will be stimulated in elderly subjects compared with the young, as the available pool of sensory axons is diminished. This means that in the elderly a greater stimulus strength is required to recruit a critical number of sensory axons.

FUNCTIONAL IMPLICATIONS

Speech

Various investigators have studied the influence of age on lingual vibrotactile acuity, spatial acuity at the lip vermillion,

palatal sensitivity, and oral perceptual skills.^{48–51} These all seem to be diminished in the older population and may have consequences on articulation of speech.

Hand grip

Impaired spatial acuity at the fingertips probably has an effect on hand motor function in the elderly, as it is probable that tactile and proprioceptive sensory deficits can result in impairment in manual control³²; the strong relation between spatial resolution thresholds and dexterity scores suggest that impaired spatial acuity at the fingertips may translate into greater difficulties with tasks requiring fine manipulations.³³

Ageing has a separate degenerative effect on hand function including decline in hand and finger strength, the ability to control submaximal pinch force, and to maintain a steady precision pinch posture and manual speed,⁵⁴ and of course the effects of degenerative joint disease, which is generally commoner with age.

Postural stability

Several studies have looked at age related changes affecting touch sensation and its impact on postural stability in the elderly. Peripheral sensation seems to be the single most important factor in maintenance of static postural stability⁵⁵ and reduced foot tactile sense in the elderly contributes to postural instability along with deprivation of visual information and great toe pressure feedback.⁵⁶ Others have highlighted the importance of somatosensory input and muscle strength in the maintenance of postural stability in the elderly.⁵⁷

Age has an important impact on the force applied to the fingertips when used as a source of sensory information to improve postural stability. Although largely preserved in healthy older adults, higher contact forces may be required to achieve postural stabilisation, and this can be interpreted as a compensatory strategy used to overcome the age related loss in tactile sensation.⁵⁸

The effect of ageing on postural stability is multifactorial and complex. Comorbidity with arthritis (causing impaired joint function) and cerebrovascular disease (affecting central control of balance and motor function) are far commoner in the elderly, and will undoubtedly also affect postural stability.

CONCLUSION

Tactile thresholds of various modalities are increased in normal ageing. It is clear that loss of sensory acuity can impact on various aspects of function in the elderly, including articulation of speech, hand grip, and postural stability. This, in conjunction with comorbid conditions such as arthritis and cerebrovascular disease, could explain the wide range of deficit seen among the ageing population. It is important to appreciate the effect of ageing on the nervous system and to distinguish these from pathological conditions, such as neurodegenerative disorders.

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